AD P000895

RETENTION OF ARMOR PROCEDURES: A STRUCTURAL ANALYSIS

John E. Morrison

ARI Field Unit - Fort Knox

Over the last few years the nature of armor tasks has changed rather dramatically. In older tanks, tasks such as ranging to the target and leading a moving target have a large skill component. With the advent of the laser rangefinder and automatic lead components built into modern fire control systems, these tasks have become largely automated and thus easier to execute. However, the pre- and post-operation procedures required by these sophisticated systems are quite complex and difficult to learn. Complicating this training problem is the fact that procedural skills are particularly susceptible to forgetting over periods of no practice. Because of the importance of procedural skills to armor performance, the ARI Field Unit at Fort Knox has been involved in developing methods for training and sustaining procedural skills.

As a basis for this research program, Morrison and Goldberg (1982) presented a model of the memory structure which underlies procedural task performance. The model assumed that memory for a procedure is hierarchically organized around task goals. In the present study, this model was tested by a proximity analysis of soldiers' recall. Proximity analysis (Friendly, 1979) is based on the assumption that items grouped together in memory tend to cluster together at recall. To perform this analysis, estimates of temporal or ordinal proximity are obtained on an item-by-item basis. The proximities are then subjected to a hierarchical cluster analysis, the result being a graphical representation of memory structure. This technique was applied to the verbal recall and hands-on performance of armor procedures. It was predicted that soldier responses would cluster about discernible task goals.

A significant characteristic of procedural skills is their tendency to be forgotten over time. For instance, Osborn, Campbell, and Harris (1979) documented declines in armor task performance over the period between basic training and field unit assignment. Perhaps such decrements in skill are associated with changes to memory organization. To investigate this possibility, memory structures produced by armor crewmen in the final phase of entry-level training were compared to structures of armor crewmen assigned to an operational field unit.

METHOD

Testing Procedure

Two groups of armor crewmen participated in the present research project. One group was made up of 12 soldiers from the 1st Armor One Station Unit Training Brigade at Fort Knox (OSUT soldiers). The second group consisted of 12 soldiers drawn from the 194th Armored Brigade, a Forces Command unit at Fort Knox (UNIT soldiers).

Soldiers were tested on six procedures in all, but results from only two were reported here. (Results from all six tasks were presented in Morrison, 1982.) The representative tasks were to clear the M240 coaxial machine gun and to put the AN/VRC-64 tactical FM radio into operation. Soldiers were first asked individually to recall the procedures in a step-by-step manner while a tester recorded their responses on audio tape. Then, they were given hands-on tests on the same tasks. Hands-on performance was video-taped by another tester. Later, the audio and video tapes were transcribed into written protocols.

Proximity Analysis

According to Friendly's (1979) technique, proximity can be measured in terms of the differences in ordinal positions of recalled items or in terms of inter-response times. The choice of measures depended on the sequence demands of the task.

The elements of the clear task had to be performed in a fixed order, and, for the most part, soldiers recalled the procedural elements in that sequence. Consequently, adjacent elements in the protocols all had a proximity of one with respect to output order. In contrast, the time intervals between protocol elements were free to vary between subjects. For the clear task, then, proximities were defined in terms of inter-response times. However, inter-response proximities could be obtained for verbal recall and not for hands-on performance. Two problems prevented measurement of times between hands-on responses. First, the onset and offset of a response element could not be reliably observed within the fluid series of actions which comprise hands-on performance. Second, factors other than memory organization (e.g., spatial location of parts) affected inter-response times. Thus, the memory structure for the clear task was derived from verbal recall and not hands-on performance.

In contrast to the clear task, elements of the radio operation procedure could correctly be performed in various orders. Consequently, both inter-response times and output order could have been used as measures of proximity. However, output order had two advantages over inter-response times under these circumstances. First, output order was a more stable measure than inter-response time, especially without restrictions on response order. Second, output order could be measured for hands-on performance as well as verbal recall, allowing comparisons of memory structures derived from both modes of performance. Thus, output order was used for this task to derive two memory structures based on verbal and hands-on performance.

Proximities for every pair of elements were computed by taking the median of the inter-response times (clear task) or the mean of the differences in output order (radio operation task). Medians were used in the clear task because of the marked positive skew of the inter-response times. The central tendencies of the soldier proximities were then entered into element-by-element proximity matrices. A hierarchical cluster analysis was then applied to these data. The order of elements for the clear structure (left-to-right) was simply the prescribed sequence for the clear task. For the radio operation procedure, however, the displayed sequence was determined by the transition probabilities generated by the soldiers' performance.

RESULTS AND DISCUSSION

Table 1 contrasts OSUT and UNIT groups on the mean number of total

Table 1
Mean Errors in Response

Tasks	Group OSUT	UNIT	*p*
	Verbal Recall		
Clear the M240	1.4	3.2	<.01
Operate the AN/VRC-64	0.8	6.0	<.001
	(Hands-On Performance)		
Clear the M240	0.6	1.4	N.S.
Operate the AN/VRC-64	1.0	3.6	<.01

errors committed while either recalling or performing the procedures. As can be seen, UNIT soldiers made more errors than OSUT soldiers on every task. *T*-tests revealed these differences to be significant except for the contrast of hands-on performance on the clear task. These results provided further evidence that procedural skill performance does decline over the period from entry-level training to field unit assignment. Furthermore, the group differences in accuracy of verbal recall parallel the differences in hands-on proficiency.

The hierarchical structures derived from verbal recall of the clear task are shown in Figure 1. Both OSUT and UNIT structures indicate that task elements are organized around discernible, temporal subgoals. It can be seen that both structures are segmented into two high-level sequential subgoals. Elements of the first group relate to the removal of all sources of ammunition from the weapon. The second group of elements pertains to returning the weapon to a safe state after unloading. As can be seen, some of the intermediate hierarchical connections differ between OSUT and UNIT structures, but the lowest level relations show exactly the same pairings of elements. These first-order relationships reflect a few mechanical and safety rules which serve as basic constraints to order: (a) The safety must be in FIRE in order to move the bolt either forward or backward; (b) to prevent accidental discharge, the safety must be in SAFE before opening the cover; and (c) the firing chamber is accessed by lifting the feed tray.

The OSUT and UNIT structures for the radio operation procedure are shown in Figure 2. In contrast to the temporal organization of the clear task, recalled elements of the radio operation procedure are organized around the spatial relationships between the AN/VRC-64 components. In both OSUT and UNIT structures, there are three discernible subgoals which relate to major radio components: connect/adjust the audio accessories, operate the audio frequency amplifier, and operate the radio-transmitter. The latter two subgoals are joined at a superordinate level presumedly because the audio frequency amplifier is located on top of the radio-transmitter, both of which are separated in space from the crewman's control box and audio accessories. Even at the lowest hierarchical level, the spatial organization is still obvious. For instance, the elements "adjust RT volume" and "set function switch on SQUELCH" do not have to be performed in any particular order. However, because the volume control and function switch are located close together on the radio

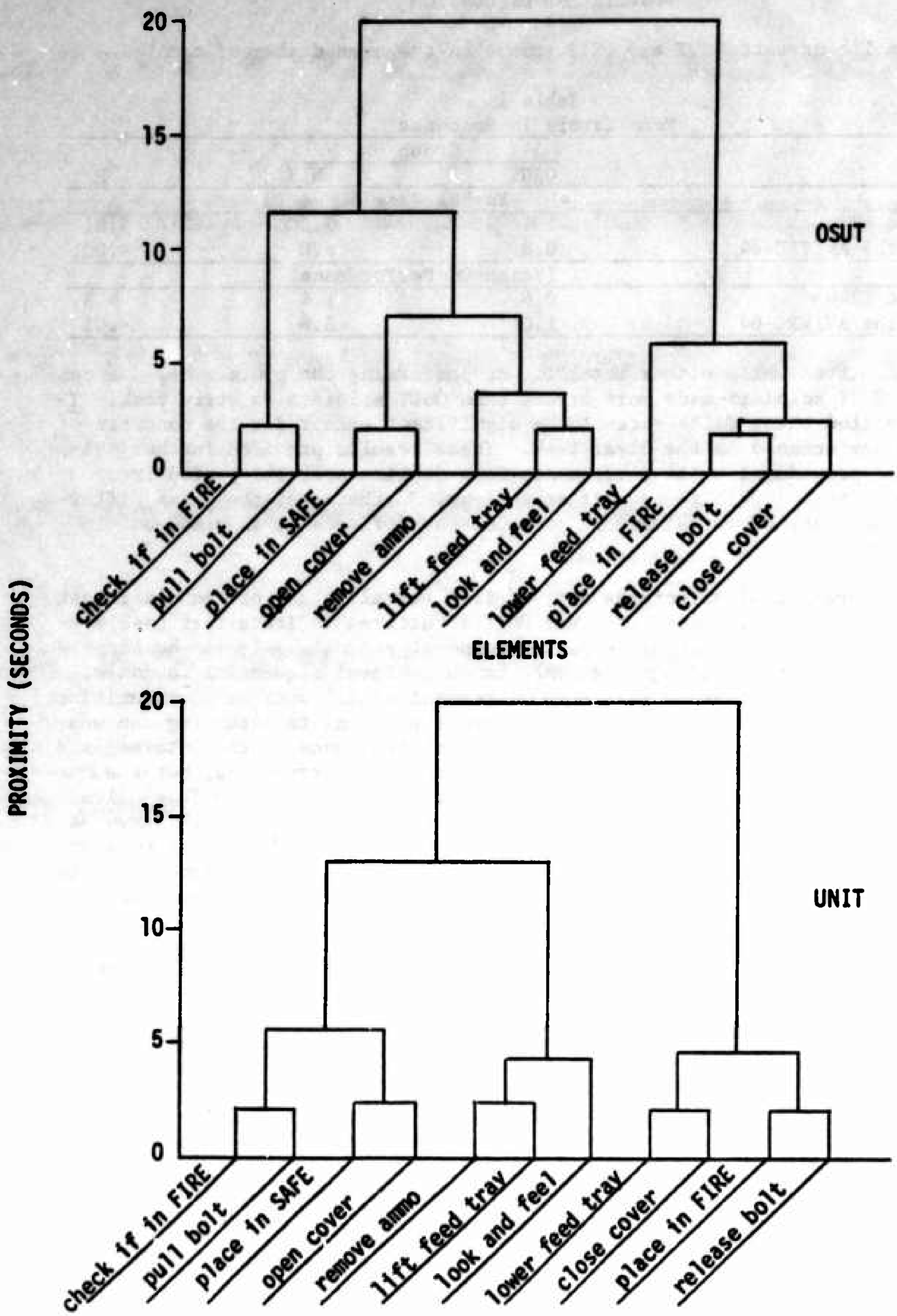

Figure 1. Hierarchical structure for verbal recall of the clearing task.

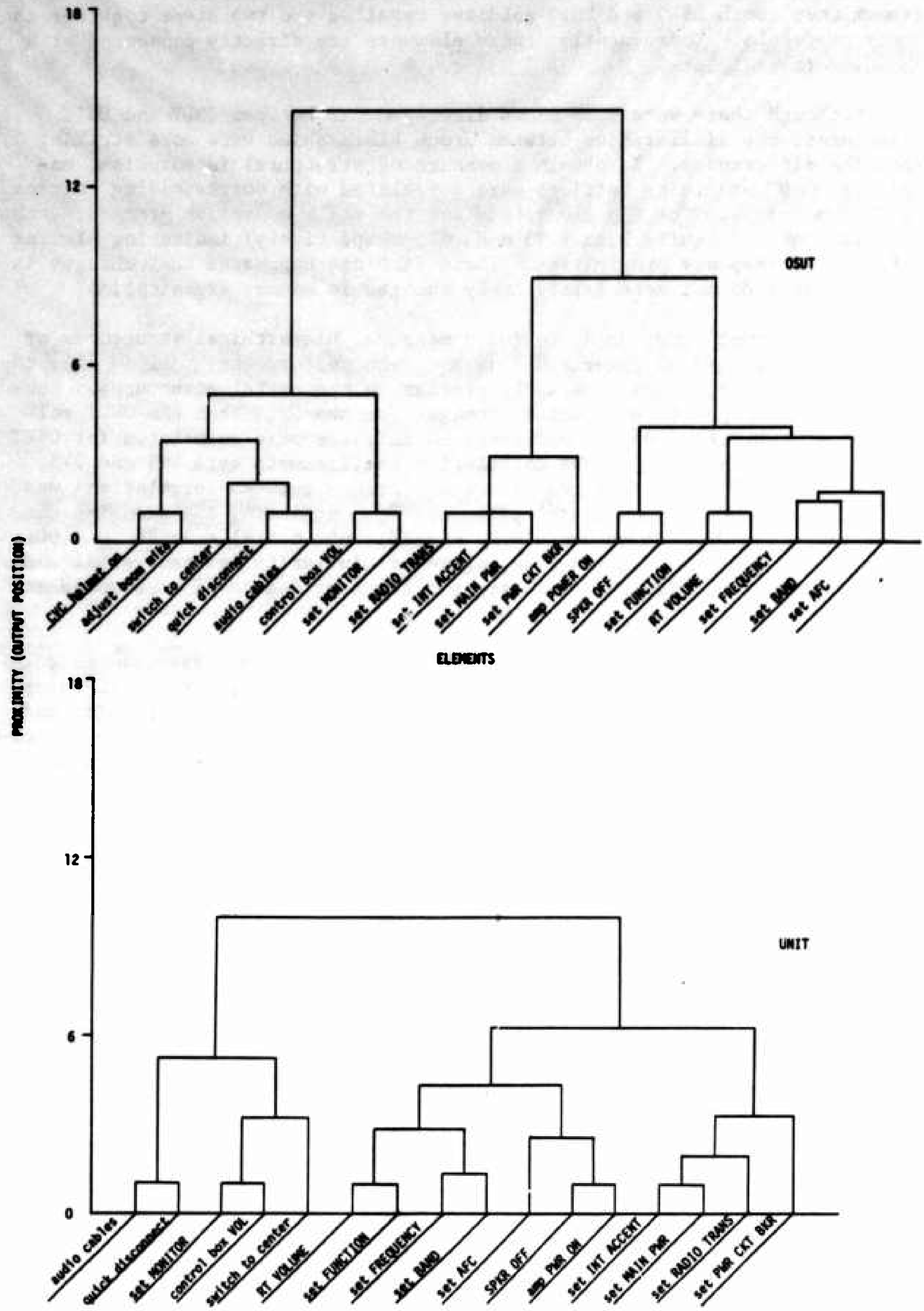

Figure 2. Hierarchical structure for verbal recall of the radio operation task.

transmitter, both OSUT and UNIT soldiers recalled the two steps together in their protocols. Consequently, these elements are directly connected at a low hierarchical level.

Although there were some minor discrepancies between OSUT and UNIT structures, the similarities between group hierarchies were more striking than the differences. To obtain a measure of structural isomorphism, entries in OSUT proximity matrices were correlated with corresponding entries in UNIT matrices. For the clear task and the radio operation procedure, the correlations were quite high (.93 and .82, respectively) indicating similar patterns of response proximities. These findings suggested that changes in recall levels do not necessarily imply changes in memory organization.

Using output order as a proximity measure, hierarchical structures of the radio task were also derived from hands-on performance. All in all, the hands-on structures were remarkably similar to the verbal structures. However, the correspondence appeared stronger for the UNIT than the OSUT soldiers. To test this, verbal and hands-on matrices were correlated for OSUT and UNIT data separately. The correlation coefficients were .95 and .75, respectively. The significance of the difference between correlations was tested by using the "jack-knife" procedure for estimating the sampling distribution. The difference was highly significant, $\underline{t}\ (14) = 23.70$, $\underline{p} < .001$. The analyses thus confirmed a high degree of similarity between verbal and hands-on structures for OSUT soldiers but a lesser degree of correspondence in the UNIT structures.

Research has indicated that making learners aware of task structure increases response organization and improves recall. Thus, structural information garnered from proximity analyses may be used to aid in training and sustaining procedural skills. However, to apply this information to a real-world training situation, task goal structures must be presented in a way that is comprehensible to trainers and students with a minimum of explanation. Future research will be addressed to designing structural training aids and determining how such aids can best be incorporated into procedural training.

REFERENCES

Friendly, M. Methods for finding graphic representations of associative memory structures. In C. R. Puff (Ed.), Memory organization and structure. New York, NY: Academic Press, 1979.

Morrison, J. E. Retention of armor procedures: A structural analysis (Draft Report). Alexandria, VA: US Army Research Institute for the Behavioral and Social Sciences, April 1982.

Morrison, J. E., & Goldberg, S. L. Toward a cognitive approach to armor procedural training (Draft Report). Alexandria, VA: US Army Research Institute for the Behavioral and Social Sciences, March 1982.

Osborn, W. C., Campbell, C. H., & Harris, J. H. The retention of tank crewman skills (Research Rep. 1234). Alexandria, VA: US Army Research Institute for the Behavioral and Social Sciences, December 1979.